

**National Aeronautics and Space Administration
(NASA)
Acquisition Pollution Prevention (AP2) Office**

**Isocyanate Hazard Control Plan For
Stennis Space Center, MS**

**For Validation of Alternatives to Aliphatic
Isocyanate Polyurethanes
Field Test Evaluations**

FINAL
NAP2.PROJ.HCP.AIU.PL.07.01.05.F

August 1, 2005

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1. INTRODUCTION

NASA and Air Force Space Command (AFSPC) have similar missions and therefore similar facilities and structures in similar environments. Both are responsible for a number of facilities/structures with metallic structural and non-structural components in highly and moderately corrosive environments. Regardless of the corrosivity of the environment, all metals require periodic maintenance activity to guard against the insidious effects of corrosion and thus ensure that structures meet or exceed design or performance life. The standard practice for protecting metallic substrates in atmospheric environments is the application of an applied coating system. Applied coating systems work via a variety of methods (barrier, galvanic and/or inhibitor) and adhere to the substrate through a combination of chemical and physical bonds.

The most common topcoats used in coating systems are polyurethanes that contain isocyanates. Isocyanates are compounds containing the isocyanate group (-NCO). They react with compounds containing alcohol (hydroxyl) groups to produce polyurethane polymers, which are components of polyurethane foams, thermoplastic elastomers, spandex fibers, and the polyurethane paints used in NASA and AFSPC applications.

The Occupational Safety & Health Administration (OSHA) states that the effects of isocyanate exposure include irritation of skin and mucous membranes, chest tightness, and difficult breathing. Isocyanate exposure may lead to skin and lung sensitization. Isocyanates are classified as potential human carcinogens and are known to cause cancer in animals. The main effects of overexposure are occupational asthma and other lung problems, as well as irritation of the eyes, nose, throat, and skin.

The primary objective of this effort is to demonstrate and validate alternatives to aliphatic isocyanate polyurethanes. Successful completion of this project will result in one or more isocyanate-free coatings qualified for use at AFSPC and NASA installations participating in this project.

The Field Test Plan (FTP) defines the field evaluation and testing requirements for validating alternatives to aliphatic isocyanate polyurethanes and supplements the NASA AP2 Office Joint Test Protocol (JTP) entitled *Joint Test Protocol for Validation of Alternatives to Aliphatic Isocyanate Polyurethanes*, prepared by ITB. The field evaluations will be performed at Stennis Space Center, Mississippi, under the oversight of the Project Engineer. Additional field evaluations may be performed at other NASA centers or AFSPC facilities.

Field evaluations demonstrate comparative field performance of candidate coating systems when applied on operating structures. The field evaluations will be performed in conjunction with the laboratory tests as specified in the Joint Test Protocol. Coating evaluators will complete a written evaluation and documentation checklist to organize and quantify the observations of coating system performance under actual operating conditions.

2. Coating Application

In order to get a true comparison of the isocyanate-free alternatives with the isocyanate containing baseline materials, it is necessary to apply the baseline materials along side the alternatives for field evaluation.

The baseline materials for this project were Carboline Carbothane 134 HB and ICI Devoe Devthane 359 DTM from the approved products list contained in NASA Technical Standard NASA-STD-5008A, *Protective Coating of Carbon Steel, Stainless Steel, and Aluminum on Launch Structures, Facilities, and Ground Support Equipment*, dated January 21, 2004.

The coating systems selected as the controls for testing are:

- Cathacoat 304 (Primer), Devron 201 (Intermediate Coat), and Devthane 359 DTM (Topcoat) produced by ICI Devoe Coatings Co.
- Carbozinc (CZ)-11HS (Primer), Carboguard 893 (Intermediate Coat), and Carbothane 134 HB (Topcoat) produced by Carboline Company.

Each testing surface shall be 3 ft × 3 ft. All coatings shall be applied under the direction of a NACE Certified Coatings Inspector. Coating process parameters, including application method and cure schedule, shall be documented at the facility that prepares the test areas using the “Coating System Field Evaluation and Inspection Report” (Appendix A of the FTP), or an equivalent form.

Each coating system will be prepared and applied according to instructions provided by the manufacturer. Coating systems should be applied by spraying to the dry film thickness recommended by the coating manufacturer. The coating system may be applied in one or two coats if allowed by the manufacturer and provided that the manufacturer’s instructions are carefully followed. Unless otherwise specified, the topcoat should be applied to the total dry film thickness recommended by the coating manufacturer.

3. Health and Safety Issues Associated With Baseline Materials

Each baseline material was evaluated to determine concerns related to safety and occupational health issues using the product Material Safety Data Sheets (MSDS), each alternative was evaluated using the following criteria:

- *Acute Effects (short term)*
- *Chronic Effects (long term)*
- *Inhalation*
- *Skin contact*
- *Eye contact*

3.1 Carboline Carbothane 134 HB

- *Acute Effects (short term)*
 - May cause dizziness, headache or nausea if inhaled
- *Chronic Effects (long term)*
 - Contains SILICA which can cause cancer
 - Reports have associated repeated and prolonged overexposure to solvent with permanent brain and nervous system damage
- *Inhalation*
 - Harmful if inhaled, may affect the brain or nervous system causing dizziness, headache or nausea
 - May cause nose and throat irritation
- *Skin contact*
 - May cause skin irritation
- *Eye contact*
 - May cause eye irritation

3.2 ICI Devoe Devthane 359 DTM

- *Acute Effects (short term)*
 - Contains a chemical that may be absorbed through skin
 - Free diisocyanate may cause allergic reaction in susceptible persons
- *Chronic Effects (long term)*
 - Possible human carcinogen (carbon black and ethyl benzene)
 - In a 2-year inhalation study conducted by the national toxicology program (NTP), ethyl benzene vapor at 750 ppm produced kidney and testicular tumors in rats and lung and liver tumors in mice (the relevance of these results to humans is not known)
 - High exposure to xylene in some animal studies, often at maternally toxic levels, have affected embryo/fetal development (the significance of this finding to humans is not known)
 - Reports have associated repeated and prolonged overexposure to solvents with permanent brain and nervous system damage
- *Inhalation*

- Irritation of respiratory tract
- Possible sensitization to respiratory tract
- Prolonged inhalation may lead to mucous membrane irritation, fatigue, drowsiness, dizziness and/or lightheadedness, headache, uncoordination, nausea, vomiting, chest pain, blurred vision, flu-like symptoms, coughing, difficulty with speech, central nervous system depression, anesthetic effect or narcosis, difficulty of breathing, allergic response, tremors, severe lung irritation or damage, liver damage, kidney damage, pneumoconiosis, loss of consciousness, respiratory failure, asphyxiation, death
- *Skin contact*
 - Irritation of skin
 - Possible sensitization to skin
 - Skin contact may result in dermal absorption of component(s) of this product which may cause drowsiness, dizziness and/or lightheadedness
 - Prolonged or repeated contact can cause dermatitis, defatting, blistering, severe skin irritation or burns
- *Eye contact*
 - Irritation of eyes
 - Prolonged or repeated contact can cause conjunctivitis, blurred vision, tearing of eyes, redness of eyes, severe eye irritation or burns, corneal injury

4. Special Precautions

Based on the above evaluation, the following Special Precautions [Personal Protective Equipment (PPE) and Administrative Controls] required for each material was identified and will be used during the application process.

4.1 Personal Protective Equipment (PPE):

- *Respiratory:* NIOSH approved Full facepiece Supplied-Air Respirator (SAR) operated in a pressure demand or other positive pressure mode providing grade D breathing air at a minimum. The use of respiratory protection will be in accordance with 29 CFR 1910.134 to include medical exam, fit testing, training, and a worksite specific written plan.
- *Skin:* All dermal exposures to isocyanate containing compounds should be prevented. In accordance with 29 CFR 1910.132 (OSHA's PPE Standard), employees should be provided protective clothing, gloves, and footwear that is impervious to isocyanate-containing compounds. Butyl rubber, nitrile rubber, or neoprene gloves are recommended and should be elbow-length (gauntlet). Disposable Tyvek or other disposable coveralls, the open points at the interface between protective clothing, e.g., the opening that forms between the sleeve of a protective suit and a glove, should be sealed to prevent exposure through interface; if coveralls do not have hoods then personnel should wear a paint sock to keep paint aerosol from contacting skin on the head and neck; safety shower or washing facility required. Shoe covers should be used whenever there is a chance of footwear contamination from spillage or splashing. Safety toe shoes/boots should be worn in industrial work areas. Although not delineated here, appropriate PPE should also be used during non-spray times, e.g. during cleanup work.
- *Eye:* Full face respirator for spray application; splash goggles with faceshield when mixing components; eyewash required
- *Hearing:* Use of appropriate hearing protection devices, e.g. disposable ear plugs, will be in accordance with 29 CFR 1910.95 (OSHA's Hearing Conservation Standard).

4.2 Administrative Controls

- *Training:* Personnel must receive training on the hazards presented by isocyanate containing paints in accordance with 29 CFR 1910.1200 (OSHA's Hazard Communication Standard). MSDSs for these paints must be accessible to personnel involved in the testing. Personnel wearing respiratory protection will have training in accordance with 29 CFR 1910.134 (OSHA's Respiratory Protection Standard). Personnel will receive training on proper use, storing and maintenance of PPE used.
- *Barricades:* Barricades and signs should be used at or outside the control area to prevent unprotected personnel from entering the test area. Use of barricades and signs should be in accordance with local safety requirements. The test area

should be limited to essential personnel. Any essential personnel entering the controlled area during spraying, e.g. helpers, should be attired in equivalent PPE.

- *Regulated Areas:* A 50' control area from the spray gun should be established prior to the start of the spray application. Consideration should also be given to use of a physical barrier such as a containment screen, e.g. air penetrable tarp, screen, or curtain, to prevent overspray drift in the event a 50' control is not feasible or if adjacent areas contain sensitive receptors.
- *Hygiene:* Personnel should remove dirty coveralls before exiting the work area subsequent to spraying; Personnel should not eat or drink in areas where paint is being mixed, thinned, or applied.
- *Engineering Controls:* (i.e., fans, etc): Effective engineering controls should be used whenever possible to reduce and/or eliminate worker exposure to respiratory hazards. This would include the use of a properly designed and ventilated enclosure, local exhaust ventilation or general dilution ventilation. Use of alternative application equipment (e.g., airless, HVLP, or electrostatic spray equipment) may help reduce spray mist generation during spray painting. For purposes of this testing based on the small scale and short duration nature of the testing and natural ventilation of the location, engineering controls are considered to be infeasible and proper use of appropriate PPE is considered adequate for personnel protection.
- *First Aid:* general requirements would include flush eyes with clean, lukewarm water (low pressure) at least 15 minutes, while lifting eyelids. Seek medical attention. Skin – remove contaminated clothing immediately, wash affected area thoroughly with soap and water. Seek medical attention if irritation develops or persists. Inhalation- move to an area free from further exposure. Obtain medical attention. Ingestion- do not induce vomiting. Seek medical attention. Refer to applicable MSDS for specific first aid instructions.
- *Worker Movement:* Avoid spraying in an upwind direction and spray with their back or sides to the airflow.
- *Heat stress:* Consideration should be given to the effects of heat stress. General recommendations include: Personnel should be trained on the signs and symptoms of heat strain. Possible administrative controls include but are not limited to, scheduling work for the cooler parts of the day, making available cool rest areas, and providing intermittent rest periods and water breaks, in case of need.